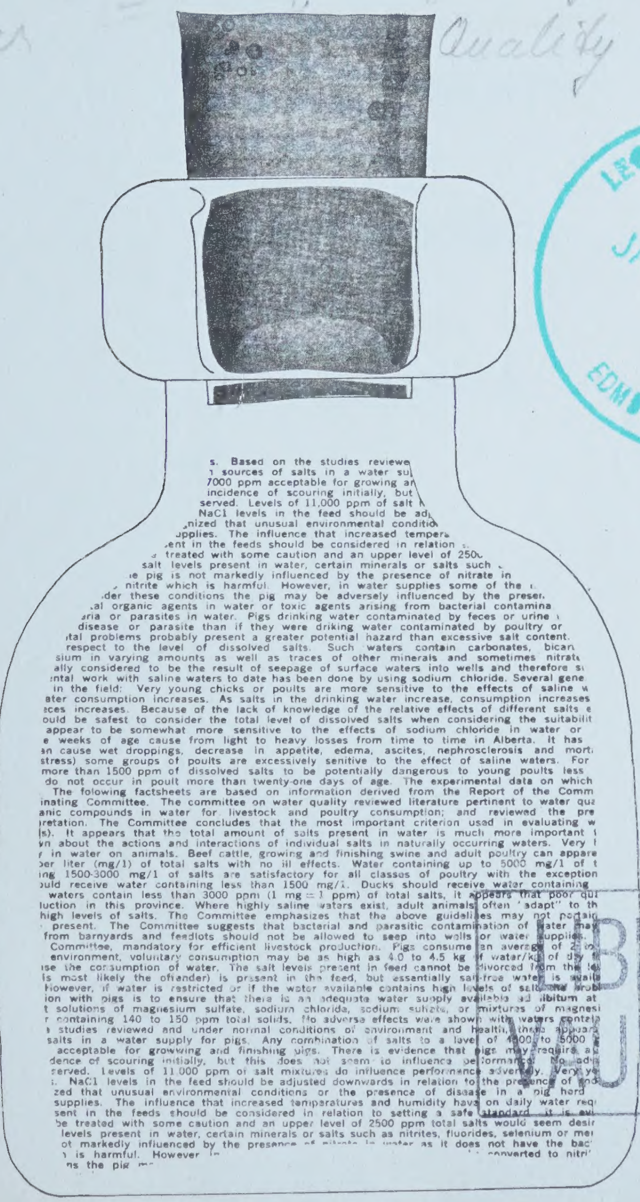
Water Quality Report

Alberta Agricultural Coordinating Committee
Water Quality Committee



ALBERTA DEPARTMENT OF AGRICULTURE 1m/7/79

WATER QUALITY

FOR LIVESTOCK

IN ALBERTA

Report of a Committee
As Presented to A.A.C.C.
January 20, 1972

TABLE OF CONTENTS

REPORT OF THE COMMITTEE ON WATER QUALITY

INTRODUCTION

The matter of water quality for livestock was first discussed by the Advisory Committee on Feed Testing at its November 30, 1970 meeting. This Committee discussed the lack of data on water quality and the difficulty of interpretation of current analyses. The Committee agreed that the matter of water quality and interpretation of water analysis reports be referred to the Animal Nutrition Sub-Committee. At its meeting on December 1, 1970 the Animal Nutrition Sub-Committee passed the following resolution: "The A.N.S.C. recommends that the Alberta Agricultural Coordinating Committee (A.A.C.C.) be requested to appoint a committee to:

1. Review literature pertinent to water quality;
2. Recommend tolerance levels of organic and inorganic compounds in water for livestock and poultry consumption;
3. Review the present procedures in Alberta for water analysis and interpretation".

The executive of the A.A.C.C. agreed that a Sub-Committee be established to deal wth the resolution and to bring a report to the next annual meeting. Dr. A. R. Robblee, Chairman of the Animal Nutrition Sub-Committee, appointed the following Committee: P. J. Martin, Chairman; Dr. G. R. Whenham; Dr. J. P. Bowland; and Dr. J. Howell.

While information on quantitative requirements of animals was not requested by the A.A.C.C. two of the three reviews contained in this report discuss quantitative requirements. It was thought that some discussion with regard to factors affecting intake would add to the report.

WATER QUALITY FOR POULTRY

Dr. J. Howell
Veterinary Services Division
Alberta Department of Agriculture

Waters obtained from bored wells in Alberta vary widely with respect to the levels of dissolved salts. Provided plenty of water is available, chickens and turkeys can tolerate fairly high levels of sodium chloride in the feed. Kare & Biely (1948) found that chicks could tolerate approximately 4% (40,000 ppm) sodium chloride in feed before showing toxic effects. Individual birds could tolerate considerably more than this. Blaxland (1946) found that 5 or 10% (50,000 – 100,000 ppm) salt in mash fed to baby chicks was highly toxic within the first week, whereas a ration containing 20% (200,000 ppm) salt fed to mature fowl did not produce mortality which could be attributed to sodium chloride poisoning. Kare & Biely (1948) showed equal toxicities for 0.3% (3,000 ppm) and 0.9% (9,000 ppm) salt in the drinking water as compared respectively to 0.8% (8,000 ppm) and 4.13% (41,300 ppm) salt in the feed.

Most experimental work with saline waters has been done by using sodium chloride. Edema but not mortality was observed in young chicks by Doll, Hull and Insko using water containing 0.5% (5,000 ppm) sodium chloride. Krista, Carlson & Olson (1960) found that 4,000 ppm of sodium chloride in the drinking water caused wet droppings and some decrease in appetite in day old chicks receiving a diet containing 0.75% (7,500 ppm) salt. At 7,000 ppm in water there was a marked increase in mortality. Kare & Biely (1948) using a ration containing 0.18% (1,800 ppm) salt showed that 3,000 ppm sodium chloride in water had no effect whilst 9,000 ppm produced heavy mortality in young chicks. Selye (1943) noted that water containing 0.9% (9,000 ppm) sodium chloride caused heavy mortality in young chicks and observed edema, ascites and nephrosclerosis.

Turkey poults appear to be somewhat more sensitive to the effects of sodium chloride in water or feed. Using a basal ration containing 0.46% (4,600 ppm) sodium chloride, Robblee and Clandinin observed losses in young poults from ascites and edema when the level of salts in water was 6,000 ppm (Mixed salts consisted of Na_2SO_4: NaCl: $NaHCO_3$ in the proportion of 3:2:1 by weight). As sodium chloride was added to the feed, losses from ascites and edema were noted at much lower levels of salts in the water. For example, when 1% (10,000 ppm) sodium chloride was added to the basal rations, ascites and edema were observed in birds being given 1500 ppm of salts in the water. At 2% (20,000 ppm) salts added to the ration, ascites and edema were observed when poults were receiving tap water with no added salts. Scrivner (1948) produced edema and ascites in young poults by giving day old poults water containing 0.5% (5,000 ppm) sodium chloride or 0.3% (3,000 ppm) sodium bicarbonate but not with 0.1% (1,000 ppm) sodium bicarbonate. The addition to the drinking water of 0.75% (7,500 ppm) of any one of – sodium nitrate, sodium iodide, sodium carbonate or sodium sulphate resulted in ascites and edema in young poults (The ration contained 0.5% (5,000 ppm) sodium chloride). Scrivner concluded that excessive sodium ions were responsible for the production of ascites and edema.

Roberts (1957) found that turkeys 31 weeks of age and 8 weeks of age showed no difference in weight gains when fed rations containing up to 4% (40,000 ppm) for periods of four weeks. The consumption of water markedly increased with the increase of salts in the ration.

Working with ducklings, Krista, Carlson and Olson found that levels of 4,000 ppm of salts in the drinking water caused growth retardation in young ducklings and watery feces. There was increased retardation and increased mortality as the level of salt in the water was raised to 7,000 ppm and to 10,000 ppm.

Waters from bored wells in Alberta contain carbonates, bicarbonates, chlorides and sulphates of sodium, calcium and magnesium in varying amounts, as well as traces of other minerals and sometimes nitrates or nitrites. Little is known about the interaction of different salts at varying levels in the drinking water, though Scrivner believed that it was the total level of sodium ions that was important in the production of ascites and edema in young poults.

Some generalizations can be made:

1. Very young chicks or poults are more sensitive to the effects of saline waters than older birds.
2. As salts in the ration increase, water consumption increases.
3. As salts in the drinking water increase, consumption increases.
4. As salts in the feed or water increase, water in the feces increases.
5. Because of the lack of knowledge of the relative effects of different salts either alone or in combination in the drinking water, it would be safest to consider the total level of dissolved salts when considering the suitability or otherwise of a water for poultry use.

Ascites and edema in young poults less than three weeks of age cause from light to heavy losses from time to time in Alberta. It has been shown that increased salts in the water and feed can cause ascites and edema. In many cases, however, high levels of salts cannot be found either in the feed or in the water and yet some remission seems to occur if snow water is used or salt removed from the ration. Because of the transient nature of ascites and edema, it is possible that the losses from ascites and edema would have stopped whether these changes had been made or not. Nevertheless, there is the suspicion that for some reason (e.g. stress) some groups of poults are excessively sensitive to the effects of saline waters. For this reason, it may be wise to consider waters containing more than 1500 ppm of dissolved salts to be potentially dangerous to young poults less than three weeks of age. Losses from ascites and edema do not occur in poults more than twenty-one days of age.

AUTHOR	TYPE OF BIRD	% SALT IN FEED	SALT IN WATER	EVALUATION
Selye (1943)	day old chicks	unknown commercial ration	9000 ppm	Ascites & edema nephrosclerosis
Doll, Hull & Insko (1946)	day old chicks	no added salt commercial ration	5000 ppm NaCl	Edema
	day old chicks	no added salt commercial ration	9000 ppm NaCl	Ascites & edema, high mortality
	day old chicks	1% salt added commercial ration	5000 ppm NaCl	Edema
	day old chicks	1% salt added commercial ration	9000 ppm NaCl	Ascites & edema, high mortality
Kare & Biely (1948)	day old chicks	0.18%(very low)	3000 ppm NaCl	no mortality
	day old chicks	0.18% (very low)	9000 ppm NaCl	Ascites-mortality less than Selye
Krista, Carlson & Olson (1961)	day old chicks	0.7%	4000 ppm NaCl	wet droppings, increased water consumption, decreased appetite
	day old chicks	0.7%	7000 ppm NaCl	wet droppings, reduced growth, significant mortality
Schrivner	day old poults	0.5% added salt	5000 ppm NaCl	Ascites & edema – mortality
	day old poults	0.5%	3000 ppm $NaHCO_3$	Ascites & edema – mortality
Bigland	day old poults	4% added salt	1500 ppm NaCl & Na_2CO_3	Ascites & edema mortality
Robblee & Clandinin	day old poults	0.46% basal ration	6000 ppm*	Ascites & edema
	day old poults	0.46% + 1%	1500 ppm	Ascites & edema
Krista, Carlson & Olson (1961)	day old poults	not specified Standard ration	4000 ppm NaCl	Increased mortality
	Laying Hens		4000 ppm NaCl	Wet droppings
	Laying Hens		7000 ppm NaCl	Wet droppings – more severe
	Laying Hens		10000 ppm NaCl	Drop in egg production
	Ducklings		4000 ppm	decrease in growth rate

*Mixed salts consisting of Na_2SO_4: NaCl: $NaHCO_3$ in proportion of 3:2:1

Livestock Sanitary Board Diagnostic Lab. evaluation of water for livestock:

Total Dissolved Solids	Rating
0 – 1000 ppm	Good
1000 – 2500 ppm	Fair
2500 – 4000 ppm	Poor
Over 4000 ppm	Unsatisfactory
Over 10000 ppm	Immediate toxic effects may be expected

South Dakota State College (1959), Bulletin 481

Total Salts Content of Water	Rating
0 – 999 ppm	Excellent
1000 – 3999 ppm	Good
4000 – 6999 ppm	Satisfactory
7000 ppm and over	Unsatisfactory

South Dakota State College (Reprint from Farm & Home Research, Fall 1962). Effects of salt content of poultry drinking water based on conductivity tests (If the ppm total dissolved salts is used in place of conductivity, the evaluation is not greatly changed).

Conductivity (Micromhos/cm)	Rating
0 – 999	Excellent for poultry
1000 – 2999	Satisfactory, may have watery feces
3000 – 4500	Poor water for poultry Watery feces – increased mortality and decreased growth, especially in poults
Over 4500	This water is considered unfit for poultry. It will always cause some kind of problem

Assessing the Suitability of Water for Livestock by C. J. Mulhearn, J. Dept. of Agric., S. Australia 61: 49-58 (1957) as reported by Dr. John B. Herrick from Feedstuffs of February 20, 1971, 48: 28.

Threshold*
Salinity Concentration

Animal	mg. per l ($\cong$ ppm)	Grains per Imp. gal.
Poultry	2,860	200
Swine	4,290	300
Horses	6,435	450
Cattle, Dairy	7,150	500
Cattle, beef	10,000	700
Cattle, adult dry	12,900	900

*Threshold: The point where a physiological effect may be produced.

Suggested evaluation for drinking water for poultry in Alberta:

Total Salts in Drinking Water	Evaluation
0 – 1500 ppm	Excellent quality for all classes of poultry
1500 – 3000 ppm	Satisfactory for all classes of poultry except for poults under three weeks of age
3000 – 4000 ppm	Not satisfactory for chicks, poults or ducklings. Satisfactory for laying hens and turkeys
4000 – 7000 ppm	Unsatisfactory for chicks, poults or ducklings. Increase water consumption and increase in watery droppings in hens and turkeys
Over 7000 ppm	Unsatisfactory for all classes of poultry

Nitrate and Nitrite

Adams, Emerick and Carlson (1966) found that water containing up to 300 ppm nitrate nitrogen or 100 ppm nitrite nitrogen was satisfactory for laying hens when used with a diet containing a good margin of vitamin A activity.

Levels of nitrate or nitrite nitrogen are usually considered to be the result of seepage of surface waters into wells and therefore suggest also possible bacterial contamination.

BIBLIOGRAPHY

ADAMS, A. W., R. J. EMERICK and C. W. CARLSON, 1966. Effects of nitrate and nitrite in the drinking water of chicks, poults and laying hens. Poultry Sci. 45: 1215-1222.

BIGLAND, C. H., 1950. Ascites and edema of brooded poults in Alberta. Can. J. Comp. Med. Vet. Sci. 14: 144-156.

BLAXLAND, J. D., 1946. The toxicity of sodium chloride for fowls. Vet. J. 102: 157-173.

DOLL, E. R., F. E. HULL and W. M. INSKO JR., 1946. Toxicity of sodium chloride solution for baby chicks. Vet. Med. 41: 361-363.

KARE, M. B. and J. BIELY, 1948. The toxicity of sodium chloride and its relation to water intake in baby chicks. Poultry Sci. 27: 751-758.

KRISTA, L. M., C. W. CARLSON and O. E. OLSON, 1961. Some effects of saline waters on chicks, laying hens, poults, and ducklings. Poultry Sci. 40: 938-944.

ROBBLEE, A. R. and D. R. CLANDININ, 1961. The effects of sodium salts in the feed and drinking water on the occurrence of ascites and edema in turkey poults. Can. J. An. Sci. 41: 161-166.

SCRIVNER, L. H., 1946. Experimental edema and ascites in poults. J. Am. Vet. Med. Assoc. 108: 27-32.

SELYE, H., 1948. Production of nephrosclerosis in fowl by sodium chloride. J. Am. Vet. Med. Assoc. 103: 140-143.

WATER QUALITY FOR PIGS

Dr. J. P. Bowland
Department of Animal Science
University of Alberta

The present edition of the NAS-NRC Nutrient Requirements of Swine (1968) indicates that pigs consume an average of 2 to 2.5 kg of water/kg of dry meal. In a high temperature environment, voluntary consumption may be as high as 4.0 to 4.5 kg of water/kg of dry feed. Under ideal conditions growing and finishing pigs will gain satisfactorily on as little as 1.5 kg of water/kg of feed, but such low levels of intake are not recommended in practice. The ARC publication on Nutrient Requirements of Pigs (1967) gives similar recommendations for water intake to those stated. It also indicates that intake will be modified by environmental factors and by dietary variables such as levels of protein, fiber and common salt. Water requirements advocated by Ensminger (1970) are considerably more generous than those suggested by either the NRC or ARC.

When feed contains high levels of salt (sodium chloride), water must not be restricted because increased urinary excretion is necessary to eliminate the NaCl (NAS-NRC, 1968). It is also pointed out that water containing 5000 mg (5,000 ppm) of salts such as NaCl of magnesium sulfate ($MgSO_4 \cdot 7H_20$) per kg of water has been fed to market pigs without causing adverse effects, although water consumption increased.

These general observations indicate that water intake is not a constant and that it tends to increase as the salt content in the water or in the feed increases. Similarly, water intake increases under high environmental temperature conditions. Therefore, tolerance levels for inorganic compounds in the water, as well as tolerance levels for any organic compounds that may have deleterious effects, must be related to the maximum consumption of water that may be expected.

Studies on saline water for pigs have been conducted at the University of Manitoba and at the University of Alberta. In addition there have been studies carried out at institutions outside of Canada and this report is an attempt to summarize the results obtained. As mentioned, in general the effect of salts in water is to increase the consumption of water. As the mammalian species must maintain an osomotic balance, extra salts in the water or the feed are going to require certain adaptive measures. Salt water toxicity resembles simple dehydration and will upset the electrolyte balance (Herrick, 1971). The salt levels present in the feed cannot be divorced from the levels present in the water. If excess salt (sodium chloride is most likely the offender) is present in the feed, but essentially salt-free water is available *ad libitum*, little problem seems to exist with pigs. However, if water is restricted or if the water available contains high levels of salts, the problem will be complicated. It has been suggested (Anon, 1959) that pigs are more susceptible to injury from saline water than are cattle. However, the following review will make this observation questionable. All natural water supplies contain dissolved mineral matter, but amounts and relative proportions of the different ions vary greatly. Bicarbonates, sulfate and chloride are the most common anions, while calcium, magnesium and sodium are found in greater quantity than the many other cations which may be present (Matz 1965).

Studies with pure salt solutions of magnesium sulfate, sodium chloride, sodium sulfate, or mixtures of magnesium sulfate and sodium chloride added to city of Edmonton water containing 140 to 150 ppm total solids were carried out at the University of Alberta (Berg and Bowland, 1960) with pigs initially weighing 12 kg. In these studies, a mineral mixture of 20% bonemeal, 40% iodized salt, 39% ground limestone and 1% zinc sulfate was made available free choice, but there was no sodium chloride added to the ration. No adverse effects were shown with waters containing up to 5000 ppm of any of the salts when performance was compared with that of pigs receiving city water.

At the University of Manitoba (Stothers and Palmer, 1961), in a series of tests, weanling pigs were fed from 12 kg to market weight on a diet which contained 0.5% (5,000 ppm) cobaltized-iodized salt and were given saline water containing between 10,800 and 21,300 ppm total solids. Two formulas were used as illustrated in Table 1.

Table 1. Calculated concentration of ions in saline water

		Formula 1	Formula 2
Ion		**ppm**	**ppm**
Calcium		625	625
Magnesium		761	761
Sodium		1,536	1,536
Bicarbonate		1,678	1,678
Chloride		1,107	4,039
Nitrate		16	16
Sulfate		4,880	908
	TOTAL	10,603	9,563

The rate of gain of starting pigs was depressed when approximately 11,000 ppm total solids were present in the water. The saline water, either predominantly 'chloride' or 'sulfate', affected the pigs most severely during the first two weeks on test, indicating that pigs can become conditioned to high salt levels in water. In growing and finishing pigs, saline waters at a level of approximately 11,000 ppm also depressed performance. However, pigs which received saline water during the finishing period only, were very slightly affected (depression of 1.2% in gain and decrease of 3% in feed efficiency). At levels above 11,000 ppm (14,800 and 21,300 ppm) the decrease in performance was much more severe and the pigs were removed from the saline water treatments before the experiments were completed.

Recent studies at the University of Manitoba (Stothers, 1970) using pigs weighing 6 to 8 kg initially and low levels of salts (2000 to 2400 ppm) dissolved in water to simulate farm water supplies gave no adverse effects. Scouring conditions reported on Manitoba farms could not be duplicated. Sulphates over 1000 ppm may have a cathartic effect on livestock, particularly younger animals (Herrick, 1971).

South Dakota studies (Anon, 1959) showed no adverse effects with growing and finishing pigs from 17 kg initial weight fed saline waters with up to 6300 ppm added salts. A salt mixture of 1 part sodium chloride and 3½ parts sodium sulfate and magnesium sulfate was added to Brookings water at levels of 0, 2100, 4200 and 6300 ppm added salts. The overall results indicate that there was no depression in feed intake, rate of gain or feed conversion with any class of pigs given up to 6300 ppm of the salt mixture (7000 ppm when the composition of the local water is considered). During the early weeks on trial there was scouring in the pigs receiving saline water but this had no adverse effect on performance.

Tests at Manitoba (Roy and Boylan, 1965) indicated that sows and litters and growing and finishing pigs showed no adverse effects when the sole water supply contained 4500 ppm of dissolved salts, predominantly chlorides.

Therefore, based on the studies reviewed and under normal conditions of environment and health, the water requirement of all classes of pigs may be met satisfactorily by waters containing various mixtures of salts up to a total of 4500 to 5000 ppm. There may be some incidence of scouring initially, but this does not seem to influence performance. For growing and finishing pigs, levels of 7000 ppm of salt mixtures appear to have no adverse influence on rate of gain or feed conversion. Levels of 11,000 ppm of salt mixtures do influence performance adversely.

It has been suggested that water becomes increasingly unpalatable as salinity increases beyond 1000 ppm total solids. Most of the work with pigs would suggest that provision of water with up to 11,000 ppm total salts causes the pigs to drink more water and to increase urinary output.

Under high environmental temperature conditions, when total water intake would increase, there is a possibility of some problem arising because the total intake might become so high that the total salt intake could not be cleared by the urine. Therefore the influence that increased temperature and humidity have on daily water requirements, along with the levels of sodium chloride present in the feeds, should be considered in relation to setting a safe standard. It is evident that the young suckling and early-weaned pig should be treated with some caution and an upper level of 2500 ppm total salts would seem desirable to be absolutely safe.

Alkalinity of water is associated with a combination of varying effects and conditions and may be related in some manner to adverse effects from high total solids intake. Although experimental evidence is not available, high alkalinity of some natural water supplies might make them less desirable than simulated waters where pure salts have been added.

In addition to the overall salt levels present in water, certain minerals or salts such as nitrites, fluorides, selenium or mercury are toxic if present above certain levels.

Iron in excess of 0.3 to 0.5 ppm will cause water to appear rusty (Matz, 1965). Occasionally iron content is so high as to make water objectionable because of its taste. Hydrogen sulfide may be dissolved in certain wells and is a most offensive contaminant to humans. There is no evidence that pigs find this particular taste and odor unacceptable even though humans do. The compound makes water corrosive to steel, copper and brass (Matz, 1965).

The pig is not markedly influenced by the presence of nitrate in water as it does not have the bacterial flora required to readily convert this into nitrite which is harmful. However, in water supplies some of the nitrate may be converted to nitrite by bacteria present in the water and under these conditions the pig may be adversely influenced by the presence of nitrite in the water.

It has been shown that conversion of nitrate to nitrite prior to consumption was necessary to produce toxic symptoms in swine and that a single dose of 0.09 g sodium nitrite per kg body weight (90 ppm) was necessary to cause death (Winks et al. 1950). Seerley et al. (1965) observed that levels of sodium nitrate providing up to 300 ppm NO_3-N in the drinking water had no adverse effect on weight gain, general thriftness, or breeding and reproductive performance in swine. Adding sodium nitrite to drinking water to provide up to 100 ppm NO_2-N gave measurable but small increases in methemoglobin at higher levels of nitrite, but was without obvious detrimental effects on performance or on liver vitamin A values. There are clinical reports in the literature of deaths from nitrite poisoning, usually from pigs that have been fed slop containing a high nitrate content which was in turn converted to nitrite during the preparation of the feed.

There are a number of potentially detrimental organic agents in water or toxic agents arising from bacterial contamination. Fecal and urine contamination may account for the presence of certain bacteria or parasites in water. The presence of coliform bacteria in water has been used as an indicator of water contamination for over 75 years (Herrick, 1971). Pigs drinking water contaminated by feces or urine from other pigs are much more likely to acquire some particular disease or parasite than if they were drinking water contaminated by poultry or livestock other than pigs. The toxins arising from blue green algae and from *Clostridium botulinum* organisms may be toxic to any class of livestock (Howell, 1961).

In a summary of a talk by Case, University of Missouri (Case, 1971) it was stated that an Iowa survey showed that shallow wells are more subject to pollution that might be harmful to livestock than are deep wells. He illustrated how proper location and maintenance of a water source and system can reduce problems with water impurities (mineral constituents) and introduced pollutants (bacteria, viruses, nitrate, pesticides, etc.). Disinfection of water for livestock may be accomplished with chlorine. Levels as recommended up to 200 ppm will not affect livestock (Herrick, 1971). Chlorinators are, however, only a means of overcoming infectious disease agents which should not be in the water in the first place.

SUMMARY

There appears to be little reason to distinguish between sources of salts in a water supply for pigs. Any combination of salts to a level of 5000 ppm is acceptable for all pigs with levels to 7000 ppm acceptable for growing and finishing pigs. Therefore most farm water supplies may be used satisfactorily for pigs, as not many samples of farm water run above 5000 ppm total solids. There is evidence that pigs may require a few days to adapt to a new water supply with some incidence of scouring initially. Very young pigs may be less able to adapt to higher salt levels. NaCl levels in the feed should be adjusted downward in relation to the presence of sodium and chloride in the water. It should also be recognized that unusual environmental conditions or the presence of disease in a

pig herd may invalidate general recommendations regarding water supplies. There is also a possible problem of nitrite poisoning or of contamination of water with some toxic mineral or from an organic material giving rise to toxins. With pigs, this is probably a greater potential hazard than is an excessive salt content. The most important consideration with pigs is to ensure that there is an adequate water supply available *ad libitum* at all times.

REFERENCES

AGRICULTURAL RESEARCH COUNCIL. 1967. The Nutrient Requirements of Farm Livestock. No. 3. Pigs. Her Majesty's Stationery Office, 40 High Holborn, London, W.C.1.

ANONYMOUS. 1959. Salinity and livestock water quality. Bul. 481, South Dakota State Coll., Brookings.

BERG, R. T. and J. P. BOWLAND. 1960. Salt water tolerance of growing-finishing swine. 39th Ann. Feeders' Day Rpt., University of Alberta, p. 14.

CASE, A. A. 1971. A summary as reported in Feedstuffs "NIFA speakers show effects of poor water in livestock production". Feedstuffs. 43(14): 4.

ENSMINGER, M. E. 1970. Swine Science, 4th ed. Interstate Publishers, Danville, Ill.

HERRICK, J. B. 1971. Water quality for livestock and poultry; A look at how physical, chemical and biological properties of water affect animals. Feedstuffs, 43(8): 28.

HOWELL, J. 1961. Toxic waters. Proc. 1st Ann. Feed Ind. Conf., Index paper 11.

MATZ, S. A. 1965. Water in Foods. The Avi Publ. Co. Inc., Westport, Conn.

NATIONAL ACADEMY OF SCIENCES – NATIONAL RESEARCH COUNCIL. 1968. Nutrient Requirements of Swine. 6th rev. ed. Publ. 1599, Washington, D.C.

ROY, G. L. and W. J. BOYLAN. 1964-65. Performance of swine on high salt content well water in the Red River Valley. 14th Rpt. on Livestock Research, Univ. Manitoba, p. 19.

SEERLEY, R. W., R. J. EMERICK, L. B. EMBRY AND O. E. OLSON. 1965. Effect of nitrate or nitrite administered continuously in drinking water for swine and sheep. J. Anim. Sci. 24: 1014

STOTHERS, S. C. 1970. Applied research papers in animal science. Univ. of Manitoba, p. 4.

STOTHERS, S. C. 1971. Water requirements of swine. Proc. Can. Soc. Anim. Sci. (In press).

STOTHERS, S. C. and W. M. PALMER. 1961. Further studies of saline water for swine. 11th Rpt. on Livestock Research, Univ. Manitoba, p. 6.

WINKS, W. R., A. K. SUTHERLAND AND R. M. SALISBURY. 1950. Nitrite poisoning of pigs. Queensland Dept. Agr. Stock., Div. Animal Ind. Bul. 2.

WATER REQUIREMENTS OF RUMINANTS

P. J. Martin
Animal Industry Division
Alberta Department of Agriculture

This review will deal with the water requirements of domestic ruminants. Both quantitative and qualitative requirements will be considered. While this review discusses both cattle and sheep, some basic differences in water metabolism between these two species should be understood. Tait (26) states that: "The water turn over rate in sheep is much slower than that of cattle and the ability of sheep to conserve water is intermediate between cattle and the camel". Sheep, according to Tait, produce urine which is much more concentrated than that of cattle. Also, sheep feces contain less water than do cattle feces.

Water requirements are met mainly by water which is voluntarily consumed, although 'metabolic water' and water contained in the feed also contribute to the supply. This review will deal only with water which is consumed voluntarily.

I Quantitative Requirements

The quantities of water which will be consumed by ruminants are influenced by the following factors:

1. Quantity of Feed (Dry Matter) Consumed

Ritzman and Benedict (23) in 1924 suggested that water consumption was highly related to feed consumption. Leitch and Thompson (15), however, concluded that water intake could not be predicted satisfactorily from dry matter intake. Winchester and Morris (32) stated that water intake of cattle is a function of dry matter intake **and** ambient temperature.

2. Ambient Temperature

Winchester and Morris (32) used calorimeter trials to determine the effect of environmental temperature on water intake in cattle.

Table 1

The Effect of Ambient Temperature on Water Intake of Beef Cattle (Winchester and Morris, 1956)

Ambient Temperature		Water Consumed (kg./kg. of dry matter consumed)
°C	°F	
−12 to +4	10 – 40	3.1
4.4	40	3.1
10.0	50	3.4
15.6	60	3.8
21.1	70	4.5
26.7	80	5.2
32.2	90	7.3

According to Church (2) the above data may not be representative of consumption levels under practical conditions, where the effects of solar radiation and increased activity of the animals may increase water requirements. Weeth (29) found that when beef heifers were provided with good quality water *ad libitum* the average level of water consumption was 4.8 kg. of water per kg. of feed. The air temperature during the experiment averaged 20 ± 3.9°C.

The A.R.C. (1) suggests that sheep (growing and fattening) will consume 2.0 kg. of water per kg. of dry matter intake (DMI) at temperatures up to 15°C, 2.5 kg./kg. DMI at temperatures of 15° – 20°C and 3.0 kg./kg. DMI at temperatures exceeding 20°C.

3. Pregnancy and Lactation

No data were found with regard to the increase in water requirements of beef cattle due to pregnancy. Winchester and Morris (32) suggested that the extra water consumed by a pregnant cow during the last 2-3 months of pregnancy corresponds to the increase in feed intake at that time. The Agricultural Research Council (A.R.C.) (1) recommends that water allowances for cattle during the last 4 months of pregnancy be 50% higher than those of non-pregnant animals. This recommendation is apparently based on data on the water requirements of pregnant sheep.

Forbes (7) found that total water intake (TWI) per unit of dry matter intake (DMI) of pregnant ewes began to increase during the third month of gestation. He reported that TWI/unit DMI was positively correlated with litter size.

Lactation certainly increases water requirements. The A.R.C. recommendation that an extra 0.87 kg. of water per kg. of milk produced be added to the water allowance of cattle is based on work done by Winchester and Morris (32).

Forbes (7) concluded that during the first four weeks of a ewe's lactation the TWI/unit DMI was greater than the sum of the TWI/unit DMI of the non-pregnant ewes and the water in the milk.

Roubicek (8) suggests that the additional water requirements of beef cows during lactation would be over 2 liters per liter of milk under "moderate environmental temperatures" and perhaps double this amount at high environmental temperatures.

4. Breed

Winchester and Morris (32) reported that European cattle *(Bos taurus)* drank more than Indian cattle *(Bos indicus)*, especially at high ambient temperatures.

Phillips (22) found that the ratio of water drunk to feed consumed was less for Zebus than for Herefords. He also reported that the decrease in feed consumption resulting from water restriction was less for the Zebus than for the Herefords.

5. Frequency of Watering

Weeth (30) compared water intakes of heifers provided with water *ad libitum* with those of heifers watered intermittently. Restricting frequency of watering to once each day and once every two days reduced water consumption

by 10% and 31% respectively. Restricting watering to once every two days reduced feed consumption by 17%; but restricting watering to once per day had no significant effect on feed consumption. The National Research Council (19) states that watering sheep every other day has decreased water consumption by 10% and has reduced gains.

6. Type of Ration

Cattle on a high protein diet drink more than cattle on a low protein diet (1) (2). Roubicek (8) attributes this increase in water consumption to the fact the higher protein level results in more nitrogenous end products which necessitate a higher urine volume. He also states that, since carbohydrates in the diet provide the most oxidation water per calorie, animals fed diets of equal protein content drink the least when the diet contains high levels of carbohydrate and low levels of fat.

Feeding high levels of salt in the ration has increased water consumption by up to 60% in cattle (32).

Suggested Quantitative Requirements

The National Research Council (18) suggests that at a temperature of 5°C (41°F) European cattle *(Bos taurus)* will consume about 3 kg. of water per kg. of dry matter ingested while at a temperature of 32°C (90°F) they will consume about 8 kg. of water per kg. of dry feed.

The following table lists the Agricultural Research Council (1) "suggested water intakes" for British conditions:

Table 2 Suggested Water Intakes (A.R.C., 1965)

Class of Stock	Environmental Temperature (°C)	Water Intake (kg./kg. dry matter consumed)
Calves (first 5-6 weeks of life)	—	6.5
Cattle (above 100 kg., not pregnant and not lactating)	−17 to +10°	3.5
	10 – 15°	3.6
	15 – 21°	4.1
	21 – 27°	4.7
	above 27°	5.5

Pregnant Cows – For the last 4 months of pregnancy multiply the above values by 1.5.

Lactating Cows (indoor feeding) – As for non-pregnant cattle (above) with an additional allowance of 0.87 kg. water /kg. milk produced.

Grazing Cows – The allowance for non-pregnant cattle times 1.5, with the additional allowance of 0.87 kg. water/kg. milk produced.

Sheep (growing and fattening)	Up to 15°	2.0
	15 – 20°	2.5
	Exceeding 20°	3.0

Pregnant Ewes — During the third month of pregnancy the values given above for growing and fattening sheep should be multiplied by 1.5. In the fourth and fifth months the above values should be multiplied by 1.8 and 2.2 respectively.

Lactating Ewes — During the first 8 weeks of lactation the values for growing and fattening sheep should be multiplied by 1.5 and during the next 8 weeks by 1.25.

Under Canadian summer range conditions the combination of low relative humidity, high ambient temperature and hot drying winds might be expected to increase an animal's water consumption to a level in excess of that suggested for British conditions.

II. Qualitative Requirements

While animals can perhaps benefit from some of the minerals contained in water, most "contaminants" of water are considered as potentially dangerous.

1. Salts

Early work (1930) by Heller and Larwood (11) on rats indicated that levels of 15,000 ppm of salts lowered growth rate while 10,000 ppm affected reproductive performance. Their findings with regard to the general additive effects of various salts, the physiological adjustment to highly saline waters and the higher resistance of older animals to salinity have been since confirmed in other species. In 1933 Heller suggested that 10,000 ppm of total salts was probably the upper limit which might be considered for a maintenance ration for cattle. He also stated that chloride salts were apparently less harmful than sulphates and alkalis were more dangerous than neutral mineral salts. He did say, however, that the total salt level was more important than the composition of the salt mixture.

In 1959 Embry and co-workers (5) investigated the effects of sodium sulphate in water for fattening cattle. Twenty-four heifers weighing an average of 304 kg. were allotted to 4 different groups each of which was fed alfalfa hay, a corn-soybean meal mixture and a mineral supplement free-choice. Sodium sulphate was added to the water (containing 530 ppm of total salts) at the following rates: 10,000 ppm; 7,000 ppm; and 4,000 ppm. The levels of 4,000 ppm and 7,000 ppm did not affect rate of gain. The animals fed water containing 10,000 ppm of sodium sulphate were taken off the high sulphate water after 56 days. The water had caused severe scours as well as incoordination and rapid, difficult respiration in two of the six animals. A third heifer died but the cause of death was unknown. The remaining five animals were given "control" water for the final 28 days of the test. Normal appetite and appearance returned rapidly. All levels of sodium sulphate reduced salt consumption. Consumption of the mineral mixture was reduced by the two upper levels of sodium sulphate. The 10,000 ppm level caused a dramatic decrease in water consumption.

Weeth and Hunter (28) found that the consumption of water containing 5,000 ppm of sodium sulphate caused heifers to drink less and eat less than heifers provided with tap water or water containing 4,110 ppm of sodium

chloride. During the 30 day feeding period the total weight gains for the tap water, sodium chloride water and sodium sulphate water groups were 19, 22 and −15 kg. These data conflict somewhat with those of Embry and co-workers; but both trials did point to the fact that sulphates are more dangerous than chlorides. Embry and co-workers (1959) also compared waters with two levels (7,000 ppm and 10,000 ppm) of sodium chloride and two levels (7,000 and 10,000 ppm) of mixed salts with a control water. The salt mixtures contained sodium chloride, sodium sulphate and magnesium sulphate. In each case 7,000 ppm of salts did not affect gain, feed consumption or apparent condition of the animals. The high levels (10,000 ppm) of both the sodium chloride and the mixed salts caused a decrease in gain but neither had the toxic effects of the 10,000 ppm of sodium sulfate in the previous experiment. The authors suggested the toxic level of total salts in the water for beef cattle was somewhere between 7,000 ppm and 10,000 ppm.

Weeth and co-workers in 1960 (28) found that water containing 20,000 ppm of sodium chloride was definitely toxic to heifers while the only effects resulting from the use of water containing 10,000 ppm of sodium chloride were an increase of 52 – 80% in water consumption and a decrease in blood urea. The water containing 20,000 ppm caused severe anorexia, weight loss, anhydremia and, in two cases, collapse.

Peirce (20) found that water containing 1.3% (13,000 ppm) sodium chloride and 0.10% (1,000 ppm) magnesium chloride had no adverse effects on wethers. In a subsequent paper (21), however, Peirce suggested that ewes and lambs may be less tolerant to saline waters than wethers. He suggested a maximum safe limit of 1.00% (10,000 ppm) salts where the salts were high in chlorides and a safe limit of 0.50% (5,000 ppm) salts where the salts were high in bicarbonates.

Embry and co-workers (5) suggested guidelines for water quality (Table 3) which apparently incorporated some margin of safety.

Table 3 Assessment of Water Quality For Livestock (Embry *et al*, 1959)

Total Salts Content of Water (p.p.m.)	Quality
0 – 999	Excellent
1,000 – 3,999	Good
4,000 – 6,999	Satisfactory
7,000 and over	Unsatisfactory

The Laboratory for Water Analysis at the University of Saskatchewan (Department of Civil Engineering) has a similar evaluation of saline waters for cattle:

Table 4 Quality of Saline Water For Livestock (University of Saskatchewan, 1965)

Dissolved Solids (p.p.m.)	Quality
0 – 1,200	Good
1,200 – 2,500	Fair
2,500 – 4,000	Poor (Usable)
4,000 – 6,000	Very Poor (Questionable)
10,000	Limit (Not Advised)

Nitrate

The presence of nitrate* in water is usually due to the contamination of the water by organic material. High levels of nitrate in animals' diets have been known to cause lowered conception rates (4), lowered rates of gain (31) and death (3) (4) (14).

Herrick (12) stated that in dairy cattle the MLD_{50} (minimum lethal dose in 50% of the cases) was about 990 mg/kg. of body weight. He suggests that waters containing 100 – 200 ppm or higher of nitrate nitrogen are potentially dangerous and that economic losses and eventual mortality result when waters containing more than 3,000 ppm of nitrate are used. Hymas and Mesler (14) reported that single doses of 737 mg. of nitrate nitrogen were lethal. They also described how heifers consumed water containing 4184 ppm of nitrate nitrogen for 90 days with no obvious problems or lowered performance. Seerley *et al* (24) found that NO_3-N levels of 300 ppm and less were not detrimental to sheep.

According to the Director of the Toxicology Laboratory (Alberta Department of Agriculture) (25) not more than 0.1% of the 10,000 water samples analyzed annually by the laboratory contain more than 100 ppm of nitrate nitrogen.

It would appear that while cattle and sheep can exist on water containing very high levels of nitrate it would be desirable to use water containing less than 100 ppm. The established limit of nitrates plus nitrites (as N) for a potable water supply for humans is 10 ppm (6) (25).

A recent suggestion (17) that nitrosamines could possibly be formed in the stomach from secondary amines and nitrite is somewhat alarming. Nitrosamines are carcinogenic and mutagenic. If, in fact, these compounds can be formed as a result of the investion of a low level of nitrite, the permitted levels of nitrate and nitrite in food and water – at least for human use – may well be reduced.

Other Contaminants of Water

i) **Blue – Green Algae** – These algae (Mycroaptis species) can produce a toxin which is quite lethal to cattle. Most losses occur during hot weather when

*In this discussion "nitrate" will be expressed as nitrate-nitrogen.

algae in bloom have been concentrated along the shore by wind (13). MacDonald (15) reported that in one case fourteen cattle out of a herd of eighty died as a result of algal poisoning. A further 20 animals from the herd exhibited signs of liver damage and photosensitization.

ii) **Fecal Contamination** – Water which is contaminated by feces is potentially dangerous to livestock since it can transmit parasitic and bacterial diseases (13). The diseases which may be transmitted in this way include salmonellosis, brucellosis, tuberculosis and leptospirosis. Parasites such as coccidia, flukes, round worms and tapeworms may also be conveyed by water.

iii) **Pesticides and Herbicides** – While pesticide and herbicide residues have not been known to cause toxicity in livestock one should realize that the misuse of such compounds (e.g. discarding containers near streams, lakes, etc.) could cause problems. The potential for such contamination increases as agricultural practices become more intensive.

Practical Implications of Water Quality To The Producer

It appears that water quality is not of great consequence to the average producer. The biggest problem for most producers is supplying adequate **quantities** of water to their animals. Perhaps, the greatest potential problems might involve the use of highly saline waters for pregnant animals or for young animals on a production ration.

In summary, water should not be a limiting factor to ruminant production if:

*1. It contains less than 7,000 ppm of total salts.
2. It contains less than 100 ppm of nitrate.
3. It does not contain fecal contamination or algal toxins.
4. It is readily available on an *ad libitum* basis.

*Animals on maintenance rations or older animals on production rations can likely cope with much higher levels (10,000 ppm).

REFERENCES

1. AGRICULTURAL RESEARCH COUNCIL. 1965. The Nutrient Requirements of Farm Livestock. No. 2. Ruminants. H. M. Stationery Office, 49 High Holborn, London, W.C.1.

2. CHURCH, D. C. 1971. Digestive Physiology and Nutrition of Ruminants. Volume 2. D. C. Church, Corvallis, Oregon.

3. CLARK, J. L., PFANDER, W. H., BLOOMFIELD, R. A., KRAUSE, G. F. and THOMPSON, G. B. 1970. Nitrate containing rations for cattle supplemented with either urea or soybean meal. J. Anim. Sci. 31: 961-966.

4. DAVIDSON, K. L., HANSEL, W., KROOK, L., McENTEE, K. and WRIGHT, M. J. 1964. Nitrate toxicity in dairy heifers I. Effects on reproduction, growth, lactation and vitamin A nutrition. J. Dairy Sci. 47: 1065-1073.

5. EMBRY, L. B., HOELSCHER, M. A., WAHLSTROM, R. C., CARLSON, C. W., KRISTA, G. F. and OLSEN, O. E. 1959. Salinity and Livestock Water Quality. S. Dak. Agr. Exp. Sta. Bul. 481.

6. FEDERAL WATER POLLUTION CONTROL ADMINISTRATION. 1968. Water Quality Criteria. Report of the National Technical Advisory Committee to the Secretary of the Interior. Washington, D.C.

7. FORBES, J. M. 1968. The water intake of ewes. Brit. J. Nut. 22: 33-43.

8. HAFEZ, E. S. E. and DYER, I. A. 1969. Animal Growth and Nutrition. Lea and Febiger, Philadelphia, Pa. (Chapter on Water Metabolism (p. 353-373) by C. B. Roubicek).

9. HANCOCK, J. 1953. Animal Breed. Abstr. 21: 1.

10. HELLER, V. G. 1953. The Effect of Saline and Alkaline Waters on Domestic Animals. Okla. Agr. Exp. Sta. Bul. 217.

11. HELLER, V. G. and LARWOOD, C. H. 1930. Saline Drinking Water. Science 71: 223-224.

12. HERRICK, J. B. 1971. Water Quality for Livestock and Poultry. Feedstuffs 43: 28-29.

13. HOWELL, J. 1961. Toxic Waters. Proceedings, Alberta Feed Industry Conference.

14. HYMAS, T. A. and MESLER, R. J. 1960. Effects of a synthetic nitrate concentrate administered orally to cattle. J. Am. Vet. Med. Assoc. 137: 477-480.

15. LEITCH, M. A. and THOMPSON, J. S. 1944. The water economy of farm animals. Nutr. Abstr. Revs. 14: 197-223.

16. MacDONALD, D. W. 1960. Algal poisoning in beef cattle. Can. Vet. Jour. 1: 108-110.

17. MASTROMATTEO, M. D. Proceedings of Symposium of Nitrogen in Soil and Water. March 30-31, 1971, University of Guelph. (Editor L. R. Webber, Department of Soil Science, Guelph).

18. NATIONAL RESEARCH COUNCIL. 1970. Nutrient Requirements of Beef Cattle. National Academy of Science, Washington, D.C.

19. NATIONAL RESEARCH COUNCIL. 1968. Nutrient Requirements of Sheep. Publication 1693. National Academy of Sciences, Washington, D.C.

20. PEIRCE, A. W. 1959. Studies on salt tolerance of sheep. II The tolerance of sheep for mixtures of sodium chloride and magnesium chloride in the drinking water. Aust. J. Agric. Res. 10: 725-735.

21. PEIRCE, A. W. 1968. Studies on salt tolerance of sheep. VII The tolerance of ewes and their lambs in pens for drinking waters of the types obtained from underground sources in Australia. Aust. J. Agric. Res. 19: 577-587.

22. PHILLIPS, G.D. 1960. The relationship between water and food intakes of European and Zebu type steers. J. Agric. Sci. 54: 231-234.

23. RITZMAN, E. G. and BENEDICT, F. G. 1924. The effect of varying feed levels on the physiological economy of steers. New. Hamp. Sgr. Exp. Sta. Tech. Bul. No. 26.

14. SEERLEY, R. W., EMERICK, R. J., EMBRY, L. B. and OLSON, O. E. 1965. Effect of nitrate or nitrite administered continuously in drinking water for swine and sheep. J. Animal Sci. 24: 1014-1019.

25. STRAUSZ, K. I. 1971. (Personal communication).

26. TAIT, R. M. 1971. Water Requirements of Sheep. C.S.A.P. Symposium "Water Requirements of Farm Livestock", July 6, 1971.

27. UNIVERSITY OF SASKATCHEWAN. 1965. Supplement to report on quality of rural water supply (mimeo.). Laboratory for Water Analysis. Department of Civil Engineering.

28. WEETH, H. J. HAVERLAND, L. H. and CASSARD, D. W. 1960. Consumption of sodium chloride water by heifers. J. Animal Sci. 19: 845-851.

29. WEETH, H. J. and HUNTER, J. E. 1971. Drinking of sulfate water by cattle. J. Animal Sci. 32: 277-281.

30. WEETH, H. J. LESPERANCE, A. L. and BOHMAN, N. R. 1968: Intermittent saline watering of growing beef heifers. J. Animal Sci. 27: 739-744.

31. WEICHENTHAL, B. A., EMBRY, L. B., EMERICK, R. J. and WHETZAL, F. W. 1963. Influence of sodium nitrate, vitamin A and protein level on feed lot performance and vitamin A status of fattening cattle. J. Animal Sci. 22: 979.

32. WINCHESTER, C. F. and MORRIS, M. J. 1956. Water intake rates of cattle. J. Animal Sci. 15: 722-740.

WATER QUALITY FOR HORSES

The committee did not review the literature for specific information on water quality for horses. However, in reviewing the literature with regard to other species none of the committee members found any scientific papers with regard to water quality for horses. There was frequent mention in various texts, however, of the fact that horses required an "ample supply of good quality water".

WATER ANALYSES IN ALBERTA

Alberta livestock producers, veterinarians or other interested persons may submit water samples to the Veterinary Services Division, Alberta Department of Agriculture for analysis.

The following analyses are performed on each sample of water: a) Total solids b) Ignition loss c) Hardness d) Sulphates (SO_4) e) Chlorides f) Alkalinity g) Nature of alkalinity h) Nitrite nitrogen i) Nitrate nitrogen (N) j) Iron k) Fluoride. Results are reported in parts per million and occasionally in grains per gallon. Bacteriological analyses on water for animal consumption are done only on request. The analysis is interpreted by a veterinarian from the Veterinary Services Division. There is no charge for this analysis.

Samples of water for human use are analysed by the Department of the Environment. Only samples submitted by Health Units are accepted for analysis. These samples are usually collected by inspectors employed by the Health Units. The results are reported in terms of milligrams per liter.

ALBERTA DEPARTMENT OF AGRICULTURE

VETERINARY SERVICES DIVISION

ANALYTICAL SERVICES SECTION

O. S. LONGMAN LABORATORY BUILDING
P. O. BOX 4370

EDMONTON 60, ALBERTA

WATER ANALYSIS REPORT
CHEMICAL

Submitted by

Date received

Address

Date reported

Source of Sample

Container No.

Serial No.

Lab No.

PARTS PER MILLION

Total Solids

Ignition Loss

Hardness

Sulphates (SO_4)

Chlorides

Alkalinity

Nature of Alkalinity

Nitrite Nitrogen

Nitrate Nitrogen (N)

Iron

Fluoride

REMARKS:

DIRECTOR, PROVINCIAL ANALYST

WATER SAMPLES SUBMITTED TO THE POULTRY SECTION (VETERINARY SERVICES DIVISION, A.D.A.) 1966-71

TOTAL SOLIDS (PPM)	NUMBER	PERCENTAGE OF TOTAL
0 — 500	47	20.5
500 — 1000	77	33.6
1000 — 2000	71	31.0
2000 — 3000	22	9.6
3000 — 4000	7	3.1
4000 — 5000	1	0.4
5000 — 6000	2	0.9
6000 — 7000	2	0.9
	229	100.0

CONCLUSIONS AND RECOMMENDATIONS

The most important criterion used in evaluating water quality is the amount of total dissolved salts (solids). It appears that the total amount of salts present in water is much more important than the types of salts contained. However, little is known about the actions and interactions of individual salts in naturally occurring waters. Very little information is available on the effects of alkalinity in water on animals.

Beef cattle, growing and finishing swine and adult poultry can apparently consume water containing up to 7000 milligrams per liter (1 mg/l $\cong$ 1 ppm) of total salts with no ill effects. Water containing up to 5000 mg/l of total salts is satisfactory for all swine. Waters containing 1500-3000 mg/l of salts are satisfactory for all classes of poultry with the exception of turkey poults under three weeks of age which should receive water containing less than 1500 mg/l. Ducks should receive water containing less than 4000 mg/l of total salts.

Since most Alberta waters contain less than 3000 ppm of total salts it appears that poor quality water is not a common problem in livestock production in this province. Where highly saline waters exist adult animals often "adapt" to them. Young animals may be less able to adapt to very high levels of salts. The above guidelines may not pertain to situations in which unusual stress or disease are present.

Bacterial and parasitic contamination of water may be a potential hazard to animal health. Surface water from barnyards and feedlots should not be allowed to seep into wells or water supplies.

The provision of water *ad lititum* is, according to the Committee, mandatory for efficient livestock production.

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